SUMMARY OF U-SPACE MICROSERVICE ARCHITECTURE EXPERIMENT:

DRONE-SPECIFIC WEATHER SERVICE

IMPETUS

1 Experiment summary

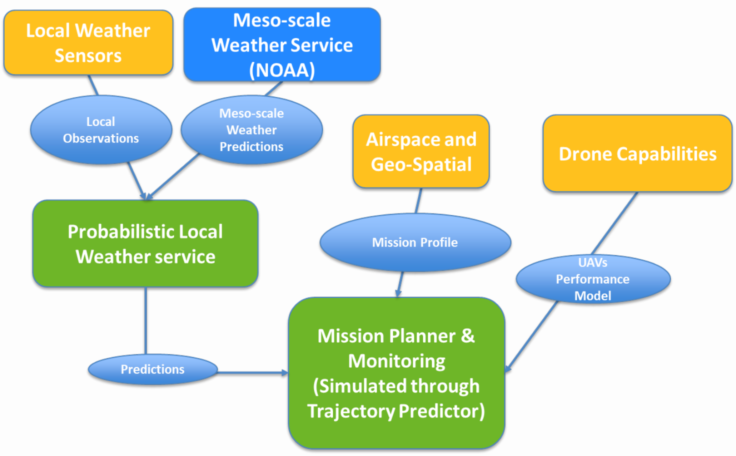
Analysis of the impact of weather forecast uncertainty on the robustness and efficiency of drone missions in U-Space

This exercise will explore how probabilistic micro-weather forecasts can be used to improve the robustness and efficiency of U-Space operations, specifically focusing on Mission Planning. To conduct the exercise, we will prototype a micro-service implementation of such a weather forecasting service and test it in relevant operational scenarios. Besides studying the potential operational benefits of such a service, we will also assess some architectural assumptions adopted to enable the service to effectively enhance Mission Planning Management as well as other U-Space services.

3 U-space architecture findings

Decoupling of weather forecasting and processing from meteorological data service provision

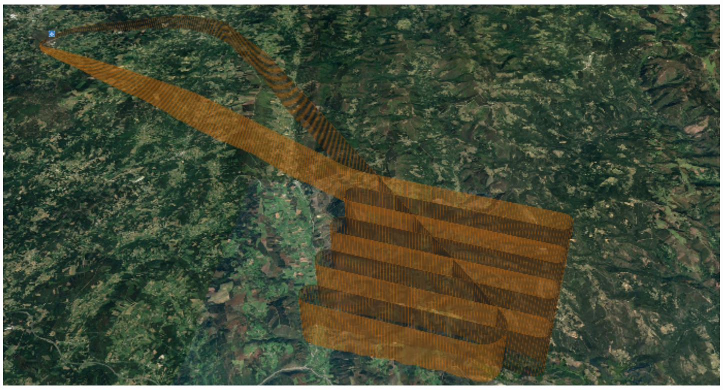
A prototype probabilistic hyper-localised weather service will be prototyped following a micro-service architecture. The main aspects to be tested will be flexibility to different client requirements, scalability as the volume of client requests grows and how the messaging solutions considered effectively support both the provision of forecasts as well as the ingestion of measures meteo data to improve the accuracy of the forecasts.



2 U-space service findings

Potential benefits of considering trajectory uncertainty due to weather in Mission Planning

The exercise will focus on simulating the mission planning phase of a surveillance scenario. The focus will be on how a probabilistic weather forecast can be used to predict the mission flight trajectory and how the uncertainty in the forecast, especially the wind, can affect the feasibility, timing and fuel burn of the mission. The objective is to understand how the Mission Plan Management service can leverage the trajectory uncertainty due to the weather to build buffers around the mission so that the objectives can be robustly achieved. For example, in the face of highly uncertain meteorological conditions the mission profile can be adjusted so that the drone trajectory remains within certain buffers and the objectives of the mission can be guaranteed to be accomplished. In the future, probabilistic meteorological hazards risks can also be considered to ensure mission safety and robustness.



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SUMMARY OF U-SPACE MICROSERVICE ARCHITECTURE EXPERIMENT:

FLIGHT PLANNING MANAGEMENT SERVICE

U-space

IMPETUS

SESAR JOINT UNDERTAKING

1 Experiment summary

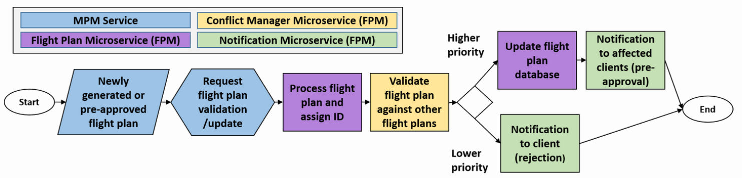
Pre-flight information exchange between U-space service and U-space service provider in an efficient implementation environment

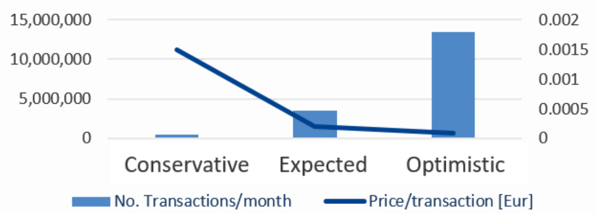
This exercise investigates how the flight plan creation, submission and validation process can be performed under a federated microservice architecture framework. A flight planning management (FPM) service serves as a centralized controlling instance that performs feasibility checks of flight plans submitted through a registered mission planning management (MPM) service instance. The complete process is tested under a realistic mission scenario and implications of the service functionalities are analysed. Additionally, the commercial implications of implementing a cloud-based U-space microservice architecture are assessed by measuring the processing time of the affected microservices within the validation process.

3 U-space architecture findings

Implementing the microservice approach, it is possible to have an initial estimation on how to bill different service requests

Each service transaction requires different computational resources and is invoked differently according to the mission type (different operational constraints). 5 typical FPM service transactions were considered. The flight plan validation/update transaction (depicted below) proved to be the most resource demanding transaction (on average 8 times higher). Furthermore, an estimation of the transaction costs has been calculated based on a forecast (2025), considering 3 projection scenarios (conservative, expected and optimistic) and by considering the microservice deployment costs in a cloud platform. With this information, the price of the flight planning transaction has been estimated.

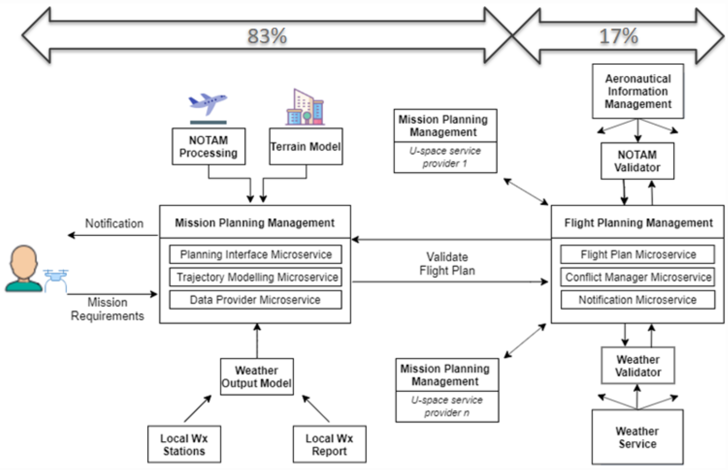




2 U-space service findings

The feasibility check of an optimized flight 4D trajectory can be safely performed by a U-space service instance

Under a delivery mission scenario the MPM Service is responsible for mission planning using a terrain model, drone capabilities and 4D trajectory optimisation for flight plan generation. On the other hand the FPM Service is responsible for flight plan check and conflict detection. Simulations of a complete planning process (up to 250 flight plan submission requests over a 60 day timeframe) have been performed. Along the tests, the distribution of time required for the completing the planning process has been measured. In average, the MPM service requested considerably large time to compute a feasible flight trajectory. In contrast, the FPM service required less time in effectively checking the flight plan and assessing trajectory conflicts in the spatial and temporal domain.



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SUMMARY OF U-SPACE MICROSERVICE ARCHITECTURE EXPERIMENT:

MONITORING AND TRAFFIC INFO SERVICE

U-space

IMPETUS

SESAR JOINT UNDERTAKING

1

Experiment summary

Performance of a microservice-based architecture in the information exchange processes envisioned for U-space

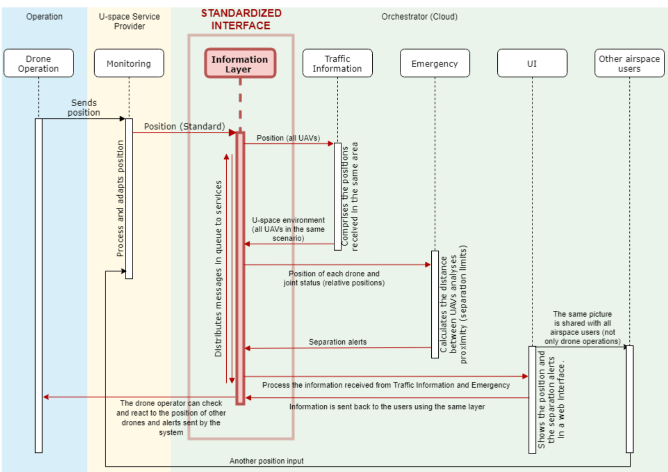
This exercise aims to test the behaviour of a simple microservice platform based on opensource technologies, simulating scenarios that will push it to the limit. Focused on Traffic Information, Monitoring and Emergency Services and simulating a variety of drone operations in a certain scenario, this infrastructure will be tested against huge variations in demand and induced service failures, testing the scalability capabilities of this architecture, the responses to unexpected events and increases in demand and the quality of service provided by the platform in limit scenarios.

3

U-space architecture findings

The necessity of a common interface for information exchange

Standardization in U-space environment is mandatory to allow users to have a complete, clear view of the scenario in which they are operating. Allowing a unique, well-defined interface to "connect with the system" will enhance the integration of all actors in the platform and promote the market entry of new services, companies and innovative solutions.



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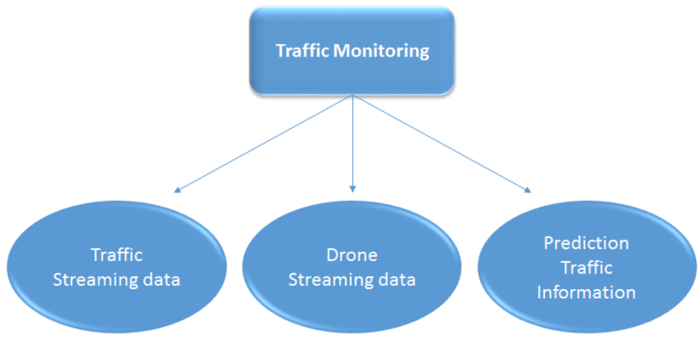
U-space service findings

Atomization of complex U-space processes in parallelized, simple functions

Decoupling all the objectives of each U-space service into simple modules is a key requirement of a complex architecture in which failures are expected. By using simple processes running in parallel and allowing redundancies, the microservice paradigm is intended to execute these tasks in an autonomous, efficient way and covering all the possible issues detected in the different scenarios (latency, unavailability, necessity of more capacity...), enabling the information exchange between them and ensuring that the information is not altered. Once an issue is detected, it is easier to reactivate simple processes rather than a complete set of functionalites.



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SUMMARY OF U-SPACE MICROSERVICE ARCHITECTURE EXPERIMENT:

TACTICAL CONFLICT RESOLUTION SERVICE

IMPETUS

1

Experiment summary

Proving efficient traffic separation through a heterogenous ecosystem

This exercise investigated the use of tactical conflict resolution to ensure separation among a set of heterogeneous drone operations, and how such operations affect the maximum airspace capacity. Through a connected 'framework' of micro-services, service capabilities and data sources can be registered and discovered by consumers.

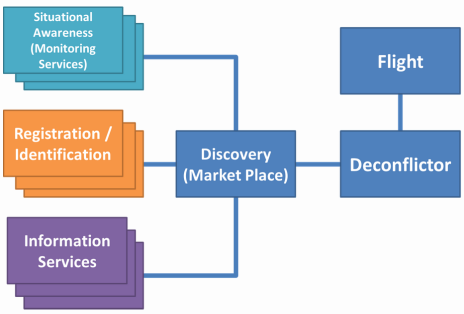
Altitude Angel's micro-services in the IMPETUS project provide a situation picture based on data provided from the other partners, and provides for registration and discovery of new capabilities. The tactical conflict resolution service identifies potential conflicts between drones, weather systems, other aircraft and dynamic airspace changes (such as TFRs) and if required, sends re-routing messages to ensure separation.

3

U-space architecture findings

Building a fabric to discover other microservices

The Discovery Service provides a mechanism through which U-space service suppliers can discover locality-specific data sources, and use them to deliver capabilities, such as conflict resolution. Within IMPETUS, we proven that it is possible to have a plethora of data sources, which can also be 'hot-swapped' during service, on-demand, due to any criteria (such as degradation or capacity).



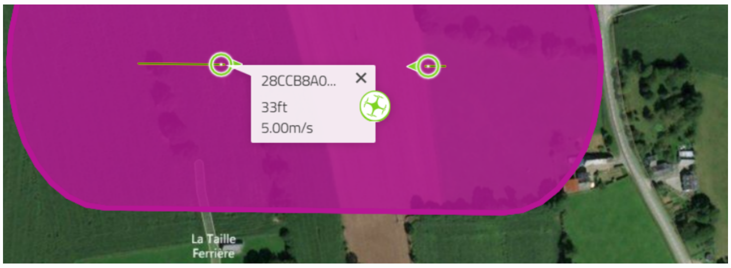
2

U-space service findings

Supporting scalability, flexibility and failure recovery

The architecture has proven it is scalable, flexible and able to manage failure. 'Region Managers' are scalable units that can adapt to changes in traffic volume by dynamically scaling their geographical extents, providing both more efficient use of server resources and airspace than traditional 'grid-based' paradigms of airspace management.

The experiment also yielded another valuable result: tactical separation, alone, is insufficient to guarantee efficient use of the airspace. Instead, intrinsic deployment of strategic planning is integral to ensuring safe navigation and giving maximum chances of success to drone missions.



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